Decadal decrease of Antarctic sea ice extent inferred from whaling records revisited on the basis of historical and modern sea ice records

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In previous work, whaling catch positions were used as a proxy record for the position of the Antarctic sea ice edge and mean sea ice extent greater than the present one spanning 2.8° latitude was postulated to have occurred in the pre-1950s period, compared to extents observed since 1973 from microwave satellite imagery. The previous conclusion of an extended northern latitude for ice extent in the earlier epoch applied only to the January (mid-summer) period. For this summer period, however, there are also possible differences between ship and satellite-derived measurements. Our work showed a consistent summer offset (November–December), with the ship-observed ice edge 1 - 1.5° north of the satellite-derived ice edge. We further reexamine the use of whale catch as an ice edge proxy where agreement was claimed between the satellite ice edge (1973–1987) and the ship whale catch positions. This examination shows that, while there may be a linear correlation between ice edge position and whale catch data, the slope of the line deviates from unity and the ice edge is also further north in the whale catch data than in the satellite data for most latitudes. We compare the historical (direct) record and modern satellite maps of ice edge position accounting for these differences in ship and satellite observations. This comparison shows that only regional perturbations took place earlier, without significant deviations in the mean ice extents, from the pre-1950s to the post-1970s. This conclusion contradicts that previously stated from the analysis of whale catch data that indicated Antarctic sea ice extent changes were circumpolar rather than regional in nature between the two periods.

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In a letter to *Nature*, de la Mare (1997) stated that there had been a 25% decline in summer (January) Antarctic sea ice between the mid-1950s and early 1970s. Figure 1 shows the 2.8° latitude apparent shift in sea ice extent for early January at 20 - 30° E longitude. Sea ice limits have been relatively constant in the era since then, although large year-to-year variability is seen on a regional basis. This conclusion was based on the use of whale catch records, as pelagic whaling was

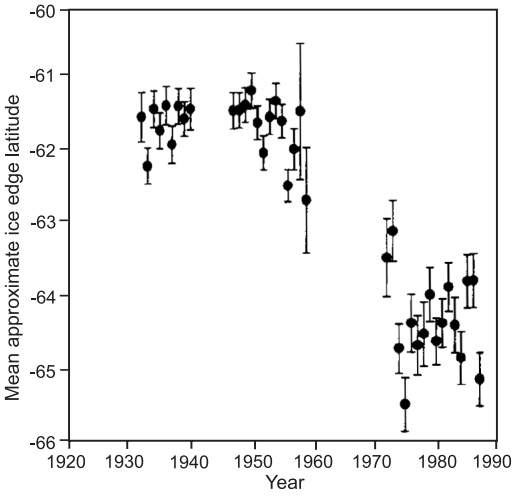

Fig. 1. The sea ice limit at 20-30° E for 1-10 January plotted as latitude vs. year covering the pre-1950s and post-1970s, based on de la Mare's analysis of whale catch records as a sea ice extent proxy (figure originally published in de la Mare 1997; used with permission of *Nature* and the author).

concentrated near the ice edge for certain species: blue (*Balaenoptera musculus*) and fin (*B. physalus*) whales in the early era, minke whales (*B. bonaerensis*) for the modern era, as reviewed in Vaughan (2000). In this paper, we compare the historical (direct) record and modern satellite maps of ice edge position; show some recent findings on the relationship between surface-based and satellite ice observations; review some of the analyses used in the whale catch records; and discuss some recent physical findings on the atmospheric driving for sea ice variability in the modern era. These comparisons, in total, suggest instead that while some regional ice extent variations both may have occurred and continue to occur, interpetating a 25% change (decline) in mean circumpolar ice extent between the 1950s and 1970s is unsupported.

Examining the direct historical record

From the 1920s to '30s, a series of cruises to the Southern Ocean was undertaken by the UK Discovery Committee with the ships *Discovery, Discovery II* and *William Scoresby.* The purpose was to investigate oceanographic properties and plankton distribution in relation to whale conservation, and results were published by the UK government in a long series of *Discovery Reports.* During this period, direct observations of sea ice extent were made when the ship encountered the pack ice. From these occasional observations, Mackintosh & Herdman (1940) compiled a circumpolar map of the monthly variation of the average ice edge. Mackintosh (1972) later updated these analyses with additional observations, probably including some made by whaling factory ships, and slightly revised the earlier maps. We note that due to the lack of whaling near the ice edge in the 1960s (de la Mare 1997) the observations used to construct these ice extent maps were exclusively from the period earlier than 1960.

Conclusions

We have relied on direct observation of ice edge position, as carried out by Mackintosh (1972) in the past, and summarized by Worby & Comiso (2001) for the present, and conclude that these must carry greater weight than observations of a quite different parameter which is affected by a host of whaling industry-based biases. We have shown in this paper that modern visual observations of ice edge position are well correlated with satellite-based data, but subject to a consistent mean offset due to diffuse ice edge satellite detectability in summer conditions. When the same offset is applied, there is good agreement between the range of modern (1979 onwards) satellite-based ice edge positions and the ship-based ice edges observed specifically by research vessels in the 1920s and 1930s for circumpolar mean latitude extent. Regional changes in summer sea ice extent between the two periods are also explainable by decadal changes in the SAM intruding warmer air and increased winds near the lower latitude ice edge in the Weddell Sea but neither increasing nor decreasing the ice extent elsewhere, due to the latitudinal asymmetry of the ice edge around Antarctica.

There is therefore no scope for a significant quantum transition in the circumpolar ice edge position in the 1960s as inferred by de la Mare from his analysis of whaling catch data as a sea ice edge proxy. Most of the difference between the earlier and later periods is explainable by the differences between ship and satellite observations and those significant changes seen are only regional variations with physical cause. We suspect the whale catch data as proxy evidence would come to a similar conclusion if the differences between ship and satellite observations are adequately accounted for and the analysis is done without an a priori assumption that circumpolar change has taken place.